INTRODUCTION TO TOUR DE TABLE PRESENTATIONS

Each country delegate presents an abstract or paper on cleaner products and processes by own choice. The trade and sector specific areas on which the CCMS meeting series focus are textile industry, organic chemical industry, the energy sector, paper and pulp industry. The focus areas for products and services are: transport, electronics, electro mechanical products, buildings, packing and energy supply. However, other pollution areas may also be addressed.

The following Tour de Table presentations are given in the chronological sequences in which they were scheduled for presentation.

SPAIN

MEMBRANE AND MEMBRANE-BASED HYBRID PROCESSES IN CLEANER PRODUCTION

Prof. José Coca
Spanish delegate

Pulp and paper effluent treatment by membrane processes

The actual concern about water pollution from industry has moved most of the countries to increase restrictions over effluent disposal. Pulp and paper industry is particularly affected because of its water requirements.

Effluent treatment and reuse is starting to be considered among the main goals for most industries. The minimization of waste water discharge reduces the environmental impact and increases savings in raw materials and chemicals. Many waste streams can be individually treated, and water reused in the process depending on quality and volume needs.

ECF bleaching effluents treatment

Bleaching stages in the pulp and paper industry are responsible for more than 50% of water pollution. Waste waters have a heavy load in terms of colour and chemical oxygen demand (COD). Classical waste treatments reduce BOD and COD, but they usually lack of colour reduction.

In this study different commercial tubular ultrafiltration and nanofiltration membranes are compared in the treatment of several effluents from the bleaching plant of kraft pulp. The research has been focused on determining the feasibility of the process in order to utilize it in industrial scale.

Water quality has been evaluated in terms of colour, COD, lignins, ionic content and carbohydrate content. Permeate flux and flux reduction due to both fouling and concentration polarization have been studied as functions of the process variables: temperature, pressure and flow rate.

Results show that nanofiltration is a reliable technique for the treatment of the bleaching effluents and their reuse in the bleach plant.

TCF bleaching effluents treatment

The use of membranes in Pulp and Paper industry has already proven to be effective for the treatment of bleaching effluents and different processes. The membranes have been used mainly to the removal of organic matter of relatively high molecular weight (10000 down to 4000 dalton). The use of nanofiltration would allow the removal of low molecular weight matter (around 500 dalton) as well as di- and tri-valent ions. In the present case, transition metals such as iron and manganese have been removed not in the ionic form in solution, but as a chelate formed with an acetic acid-based chelation agent. This work shows that nanofiltration membranes can be very useful in the reduction of waste discharges and the reuse of process water inside a pulp mill. Membranes showed chemical and thermal stability at the process conditions providing a very good selectivity and, thus, yielding good quality water.

Kraft black liquor fractionation

The most common use of Kraft black liquors is as an energy source, being burnt after a concentration, in order to produce steam and recover chemicals which are recycled to the process.

An alternative process for overflows and spillages could be the recovery of lignin and its use, or the use of some of the fractions, in the manufacture of more valuable compounds, such as adhesives, polymeric materials as polyurethanes or as fillers in composite materials. It has been shown that the molar mass (MM) distribution is the key parameter, which determines the potential use of those lignin fractions. Low MM lignin fractions could be incorporated in phenol-formaldehyde type resins, while high MM fractions are preferred for substitution of polyols in polyurethane manufacture.

Membrane processes are effective in the separation of both fractions and also allow recovering the salts, that in turn could be recycled to the pulping process.

Experiments were carried out in a tubular membrane module, using ultrafiltration membranes with nominal MWCO ranging from 4 to 100 kDa. Diafiltration experiments have been also carried out to enrich the retentate in the high MM fraction.

Removal of waste emulsified cutting oils from effluents in the metalworking industry

Oil refining and metal-finishing industries, such as rolling mills and mechanical workshops, produce large quantities of oily wastewaters that need to be treated before their disposal, because of their detrimental effects on aquatic life and their interference with conventional wastewater treatment processes. Water-based lubricants and cutting oils have gained an increasing acceptance in the metalworking industry, replacing some petroleum-based products because of their more efficient performance and less severe environmental problems. These fluids, containing mainly emulsified oil and surfactants, become less effective after use because of their thermal degradation and contamination by substances in suspension, and therefore they must be replaced periodically.

The aim of this work is the design and construction of a modular pilot plant for the treatment of different water-based coolants and oily wastewaters generated in metalworking processes and steel cold rolling operations. Different treatments are considered depending on the nature of the oily waste emulsion, such as coagulation/flocculation, centrifugation, membrane processes (micro and ultrafiltration) and sorption processes. The main advantage of this pilot plant is its versatility, allowing the combination of the aforementioned treatments, being a feasible waste management alternative from an economic point of view. This might lead to a better control of this kind of wastes and a better reuse of water, in the case of large industrial plants, with the resulting environmental and economic improvements.

Membrane-based hybrid processes

Membrane contactors

Membrane contactors represent a new way to carry out separation processes like gas adsorption and solvent extraction. They are commonly hollow fibre modules used as substitutes for packed towers. Extraction with hollow fibre modules are fast due to the large interfacial area per volume. The interface is stabilised at the membrane pores, avoiding emulsification. Dispersion-free solvent extraction has been recently studied and proved to have several advantages over conventional extractors: high surface area per volume, no need for density difference between phases to achieve phase separation, no limitations of loading or flooding, ability to handle particulate and systems that emulsify readily, no need of agitation or moving parts, and ability to provide several extraction stages in a single equipment. The main disadvantage is the slower mass transfer rate, due to the resistance to mass transfer in the pores of the membrane, which is minimised by using microporous membranes where the solute diffuses easily through the pores.

The work examined the influence of the hydrodynamics of both organic and aqueous phases on the overall mass transfer coefficient of the extraction of organic acids and phenol from an aqueous solution. A continuos extraction-stripping process has also been tested with satisfactory results.

Lactic acid derivatives

About 25% of the national production of cheese is located in the region of Asturias. This implies the production of more than 400000 t/year of whey, 87% of it coming from only seven companies.

The management of such big amounts of cheese whey is a serious problem for the dairy industry. Proteins are usually recovered by ultrafiltration, but treating the permeate as a waste before dumping represents a considerable cost. Therefore, other alternatives such as production of chemicals may be justified.

This work focuses on the valorisation of whey permeate by means of the production of lactic acid and several valuable derivatives. It includes improvement of the continuous production of lactic acid by lactose hydrolysis prior to fermentation, recovery of lactic acid from the fermentation broth by membrane extraction (pertraction) and obtaining lactic acid esters by hybrid processes involving reaction and separation.

GREECE

STATUS OF IPPC AND LCA IN GREECE
Georg Gallios
Greek delegate

Greece as a member of EU should comply with the 96/61/EU directive concerning Integrated Pollution Prevention and Control (IPPC). Actions that have been planned in order to help industries undertake the necessary actions will be presented in the meeting. The attitude of the industries towards the use of tools like LCA will be discussed. A brief description of LCA studies completed so far will also be presented. Finally, a current research project for the development of an electrochemical procedure for the removal of biologically non-degradable azodyes from the effluents of industrial processes will be described.

UNITED KINGDOM

UK SUPPORT FOR CLEAN PRODUCTS AND PROCESSES
Prof. Jim Swindal
United Kingdom delegate

It continues to be a central plank of UK Government policy to encourage and support clean and sustainable production and clean up of contaminated land.

There are a number of available initiatives including the Environmental Technology Best Practice Programme; Bio-Wise, a new programme to encourage the applications of biotechnology in industry with an emphasis on bioremediation; CLAIRE a public private partnership for the remediation of contaminated land in a sustainable way, ENTRUST an organisation to distribute revenue from landfill tax, Business in the Community which encourages companies to be more proactive in their interaction with their communities. Each region has local initiatives such as the Northern Ireland IRTU waste exchange, technical clubs, financial assistance for environmental audits and funding for environmental research, the Belfast City Council sponsored SME environmental starter pack etc.

There can be no doubt that the UK takes its responsibilities with respect to clean production very seriously as a member of the European Union and also as a responsible member of the World community. The UK record on the implementation of European environmental legislation is among the best of any member state.

DENMARK

THE ROLE AND GOALS OF THE DANISH TEXTILE STAKEHOLDER PANEL WITHIN THE PRODUCT ORIENTED ENVIRONMENTAL INITIATIVE.

Henrik Wenzel
Danish delegate

As one out of three industries in Denmark, textile industry was chosen as pilot industry for testing the feasibility of the product oriented environmental initiative. A key element was to establish a panel of essential stakeholders in the market for textile products, and have this panel itself draft a strategy for the product oriented environmental measures in the industry.

The textile panel has now, early 2000, evaluated its first year of action. In Autumn 1999, the two main activities were partly to get the industry's designers, manufacturers, ands retailers to buy the idea of developing and marketing environmentally friendly products, partly to establish a knowledge centre on environmentally friendly textiles. The initiative has been received positively by these stakeholders. The panel sees it as its most important task for the coming year to get a higher volume of environmentally friendly products with the EU Eco-label (the "flower") on the market and to motivate the purchasers and the consumers to buy these products.

The Danish tour-de-table presentations of 1998 dealt with the product oriented initiative in general. In 1999, the measures in textile industry in general were presented, and this year, it is chosen to go in depth with the role, goals and actions of the textile stakeholder panel.

POLAND

SELECTED ACTIVITIES ON CLEAN PRODUCTS AND PROCESSES IN POLAND

Andrzej Doniec
Polish delegate

An understanding of the necessity of production process improvement is growing higher in Poland. Over 200 Polish enterprises have obtained a Cleaner Production Certificate, which endorses their environmental performance. To recognize the potential for a broader implementation of the cleaner production concept, research has been done which also shows incentives and barriers to cleaner production. Almost a 100% of responding companies are interested in implementing of a waste minimization program, which is close to the number who claimed to be familiarize with the cleaner production idea. As part of the continuing effort to spread the idea, a waste minimization program for military equipment repairing enterprises has been designed and a demonstration program in one of the unit has started.
In a separate, more general approach, a list of cleaner production options for the food processing industry has been developed. The first step was done to describe waste streams currently generated by dairy sector. Some environmental and effectiveness indicators differ slightly from those of highly developed countries.

CZECK REPUBLIC

CZECH NATIONAL CLEANER PRODUCTION PROGRAM (NCPP)

Dagmar Sucharovova
Czech Republic delegate

By signing the Declaration in 1999, the Czech Republic endorsed the global program of cleaner production. Government Resolution No. 165 of February 9, 2000 created the framework for meeting this commitment.

The purpose of the National Cleaner Production Program (NCPP) of the Czech Republic is to change the approach of enterprises, the state administration and the public to the choice of measures providing for protection of the environment in industrial and other activities, including the provision of services. The program is based on the conviction that the generation of waste and pollution must be limited in the process of the activity through the implementation of changes in the technology and procedures employed. The change in the approach simultaneously

- enables limitation of construction of end technology to an essential minimum,
- ensures a higher level of utilization of input materials and energy (and consequently a decrease in demand for material resources and energy),
- optimizes expenditures for investments and for management of waste and pollution (and consequently reinforces innovative trends and the competitiveness of the product on domestic and foreign markets).

NCPP should create conditions for the implementation of voluntary activities of enterprises and organizations in the area of preventative environmental protection. The Program is based on analysis of projects and programs of cleaner production; if a business entity or other organization voluntarily implements its own program of cleaner production and the results of this program are reflected in its plans and practice, the requirements on protection of the environment, following from the Laws, can be fulfilled in an economically effective manner and can exceed the framework of these Laws. Simultaneously, the resources employed are saved and thus the effectiveness of the processes is increased.

Implementation of NCPP offers

- an improvement in the environment as a whole and introduction of an integrated approach to environmental protection as required by the IPPC Directive (Council Directive 96/61/EEC)
- an increase in competitiveness in innovation processes and a decrease in economic losses
- increased qualification of workers and the creation of new working opportunities in the area of management systems, monitoring of material, energy and financial flow in processes and in regions and also in the area of development, implementation and maintenance of cleaner production measures
- the creation of preconditions for integration of economic, social and environmental aspects of development in the individual regions and sectors.

In the Czech Republic, there is sufficient professional capacity required for commencement of implementation of NCPP, especially in the framework of the Czech Cleaner Production Centre

(CPC) and its regional centers, training cleaner production centers at universities, enterprises and cities, which introduce cleaner production programs, and the Association of cleaner production managers or professionals, who have been trained in this area as consultants and instructors. However, it will be necessary to train further professionals for every-day application of the principles of cleaner production at all levels.

Aims and Targets of the National Cleaner Production Program

The target of NCPP is to utilize information and create conditions for voluntary application of cleaner production projects (as instruments in the prevention approach) in the framework of programs announced by the individual sectors. The creation of NCPP thus reacts to the fact that

- it is necessary to ensure systematic assistance from the state in the area of protection of the environment, which will be based on preventative measures
- the increasing demands on protection of the environment as a whole require new approaches: these approaches are economically effective if they are integrated into production processes and products (they thus improve the environment and simultaneously increase the competitiveness of enterprises)
- these new approaches are complex and must be the result of close cooperation amongst the individual special-interest groups.

Thus, in the long term, NCPP will support the new trend in the "product/service - user needs" relationship, which is characterized by an increase in the importance of provision of services at the expense of the importance of the product itself. This change will be dependent on user requirements. The proposed increase in the effectiveness of the system of satisfying needs will not mean that the needs of human beings will be satisfied less, but that they will be satisfied with new quality.

The short-term target of NCPP consists in decreasing the environmental impacts of processes, products and services, with a simultaneous increase in the competitiveness of the economy. Every sector will set its own specific targets.

SLOVAC REPUBLIC

CLEAN PRODUCTS AND PROCESSES, SLOVAC REPUBLIC

Lubomir Kusnir
Slovac Republic delegate

It follows from todays economy status that following the 10 years of transformation Slovak industry and the whole economy face the need for sweeping and deep-seated restructuring. Slovakia s specific is the fact that industrial policy has to be implemented in the situation where much of the economy has to be subject to restructuring.

Under this situation, also the application of sectoral programs will be considered to help the industries that need to undergo restructuring (e.g. mechanical engineering, mining, metallurgy, textile industry, woodworking). If such an instrument is used, it will be done so in strict compliance with the EU rules on granting state aid and competition protection rules.

Companies in the Slovak republic are under the increasing competitive pressure of free-market economy, while facing the shortage of available funds and tougher environmental legislation. Companies have to operate under unstable tax and business regulations, compete for qualified working power with foreign firms, satisfy increasing compulsory fees and deliveries, manage inherited environmental problems, and incorporate new social issues.

The Slovak Cleaner Production Center had been established, aiming not only to assist in solving environmental problem for these companies, but also to achieve a change of values and priorities in relation to environment protection. As a tool to systematic approach, management and improvement, the Slovak Cleaner Production Center (SCPC) effectively uses standards for management systems –QMS according ISO 9002 and EMS according ISO 14001. Through its activities, the SCPC mainly supports project implementation mainly in small and medium-size enterprises and prefers complex solutions on regional basis.

MOLDOVA

ENERGY SUPPLY, -COMSUMPTION AND -SAVING POTENTIALS

Sergiu Galitchi
Moldovan delegate

SUMMARY

Moldova, like other countries in transition is facing many challenges. Moldova is located between the Ukraine and Rumania, and has approx. 5 mio inhabitants. The main sources of income are agriculture, product processing, electronic manufacturing, machine building, building material (cement) production.

An UNEP supported assessment was made concerning the different branches contribution to climate change. Fossil fuels account for approx. 75% of CO_2 emissions. Combustion of fossil fuels and biomass account for approx. 65-75% anthropogenic emissions of NO_2. However, production facilities are only working at approx. 40% of the full capacity

Energy supply is a major problem in Moldova. Energy is needed both for production and to improve quality of life and is essential for economical development. Moldova is dependent on electricity from the Russian Federation. Alternative energy source are interesting, i.e. solar power (Moldova has 310 days per year with sunshine), and biogas.

Energy efficiency regulation must be dynamic to evolve the technology. Savings in energy can be obtained by substituting old equipment with less energy consuming equipment. A project has been planned on substituting old pumps in municipal plants with Grundfos pumps using 30% less electricity. The pay-time for such a venture is approx. 6 months, but there has been bureaucratic hold ups. There are also large saving potentials in house hold electric appliances. Overall, energy saving potentials are very large and in many circumstances cost-effective.

The end user will see his energy bill decrease and at the same time his comfort will enhance. Energy efficiency regulation will also reduce emissions, the utility companies will easier meet he energy demand and it will delay new investments on the supply side.

ISRAEL

STANDARDIZATION AS INCENTIVE - WATER SUBSIDIARIES – HAZARDOUS WASTE

Chaim Forgacs
Israeli delegate

SUMMARY

Standardization
One of the most important single issues for large companies in Israel is to obtain the ISO 14000 certification. Very large part of the Israeli production goes to export and it becomes increasing important that exporting companies have ISO9000 and ISO 14000 certification. ISO standards might be a more effective driving force in clean products and clean processes than any governmental regulation.

Water shortage
Israel has implemented large-scale seawater desalination. There is an ongoing discussion between the Treasury and Department of Agriculture and the Water Commission concerning water shortage. The Treasury argues that there is no problem with water shortage in Israel, the problem is that water is subsidized for agricultural production, and agricultural goods are exported. If the subsidies are cut, it will put a stop to the water shortage.
However, stop of subsidies will end agriculture in Israel as know today, and it will reduce the green zones of the country, which already is under pressure due to massive constructions activities in the middle part of the country. Ways must be found to maintain agriculture in these parts of the country. Minor solutions have recently been implemented in few places e.g. small electrodialysis plants for selective removal of nitrate from municipal wells.

Hazardous waste
Waste collection stations are being set up, and waste collected all over the country is transported by train to national plants for treatment.

EDUCATION IN ENVIRONMETAL ENGINEERING AT BEN-GURION UNIVERSITY, ISRAEL

SUMMARY

The goal of the M.Sc. program in the Environmental Engineering Unit is to educate professionals to cope with environmental problems within
- enforcement – governmental, municipalities
- Obeying regulations – industrial entities etc.
- Offering special environmental services

Enrolment in the courses was in 1997≈ 50, in 1998 ≈ 25 and in 1999 ≈ 25. The unit has 5 Ph.D. students. Core courses are

1. Introduction to environmental engineering
2. Environmental chemistry
3. Environmental biology
4. Waste water control
5. Air pollution control
6. Solid waste and hazardous materials
7. Environmental laws and regulations
8. Environmental Engineering laboratory
9. Seminars with guest lectures from industry and government

Below a partial list of elective courses:

1. Environmental analytical chemistry
2. Advanced waste water control
3. Advanced air pollution control
4. Environmental management
5. ISO 14000 workshops
6. Membrane processes
7. Chemical plant design with environmental considerations
8. Green chemicals
9. Toxicology
10. Renewable energy sources
11. Environmental acoustics
12. Mathematical modelling

ITALY

RESEARCH FOR CLEAN PRODUCTIONS IN PROGRESS

E. Drioli
Italian delegate

Significant efforts are devoted to environmental control in various industrial production lines. The tentative to introduce innovative technologies along the production line in Italy and not only at the end of the pipe is becoming more traditional than in the past. National research projects under the leadership of industrial groups are in progress in the agrofood industry, in the textile industry, in the chemical industry, where the environmental aspects are very well present in each research projects.
Educational programs are carried out in parallel to each one of these projects. The sponsorship is mainly from the Ministry of University and Research.

The IRMERC - CNR is active in some of the activities with the specific objective of evaluating the possibility of membrane engineering in the razionalization of industrial production.

TURKEY

REPORT ON THE STATUS OF CLEANER PRODUCTS AND PROCESSES IN TURKEY

Akin Geveci
Turkish delegate

Turkey does not yet have an organization to promote the Cleaner Production. This is because the Turkish Legislation still foresees the end-of-pipe treatment not the pollution prevention.
This situation will change with the establishment of National Cleaner Production Centre in the very near future.

With the directive issued by The Science and Technology Supreme Committee in its meeting in June 2, 1998 a Working Group was formed to advise the national policy to promote environmental friendly technologies and environmental management systems. As a result of two years working of the group the establishment of NCPC was decided to be within TUBITAK-MRC.

The responsibilities of NCPC will be as;
-Advise the authorities on the C.P Policies and Strategies,
-Conduct and/or assign R&D on C.P. And whenever possible manage technology transfer,
-Test, analysis and certification (ISO 9000 and 14001),
-Technical and managerial consultancy,
-To establish C.P information centre,
-C.P training.
The industries which will be dealt with are textile, leather tanning, food, metal working, paper and chemical.

PORTUGAL

THE PORTUGUESE TEXTILE INDUSTRY – CLEAN TECHNOLOGY AND WASTE MANAGEMENT

Susete Martins Dias
Portuguese delegate

The Portuguese textile industry comprises about 17 000 companies operating in different sub-sectors from cotton, wool and synthetic fibres to cloth manufacturing, woollen and home textiles. Although the Representatives of the Textile Associations only refer 5196 companies with 250 000 employees.

The Portuguese textile industry represents 22% of Portuguese manufacturing industry, accounting for 20-25% of annual exports, which amounts to 50 million EURO.
Most of the companies are located in the North of Portugal, in the Ave river basin, namely in Famalicão, Santo Tirso and Guimarães. The competitiveness of these companies is threatened by the textile market liberalisation in 2005. Efforts to overcome this problem focus on process

technology innovation, accomplished by a rationalisation of the implemented capacity, marketing and human resources.

The textile industry technology innovation is being supported by The Technological Centre for the Textile and Garment Industries of Portugal (CITEVE), The National Institute for Engineering and Industry Technology (INETI), Minho and Beira Interior Universities and Instituto Superior Técnico in Lisbon, on issues like clean technology, process integration and environmental management. Several projects aimed at innovation in the textile industry were undertaken under the SIMIT programme (Incentive System for the Textile Industry Modernisation), since 1995, co-financed by the EC. An Integrated Decontamination System for River Ave region was developed which includes the wastewater treatment of more than 250 textile companies by the Public Administration.

BULGARIA

CLEAN ENVIRONMENT AND IT'S SUSTAINABLE DEVELOPMENT. WATER RESOURCES IN BULGARIA

Stefka Tepavitcharova
Bulgarian delegate

During the last years Bulgarian national policy in the field of ecology aims at: (i) preservation of the environmental status of the unpolluted and with kept natural resources areas; (ii) improvement of the quality of environment in polluted areas with disrupted natural balance.

The water resources are main part of the national nature wealth and their conservation is of extreme significance. A draft law on water has been elaborated. There are a number of national and international projects which purpose is to improve the status of water resources in Bulgaria. The investments in construction and reconstruction of wastewater purification stations and in technological renovation of production processes are defined as priority. The quality of the Bulgarian water resources (surface, ground as well as Black sea coastal water) is characterized for 3 years period using physicochemical and biological monitoring data. The result is water resources status improvement in Bulgaria in the last years.

UKRAINE

CLEANER PRODUCTION STRATEGY AND TACTICS, DEFINITION TOOLS AND METHODS BASED ON SYSTEMATIC APPROACH TO SUSTAINABLE PRODUCT DEVELOPMENT FOR SYSTEMATIC REDUCTION OF ENVIRONMENTAL LOADS (ECOLOGIZING OR "ECOLOGIZATION")

William Zadorsky.
Ukrainian delegate

This presentation is continue of 1999 year presentation "A Ukrainian's Version of a systems Approach to Sustainable Development in Environmentally Damaged Areas: Cleaner Production

and Industrial Symbiosis as Major Ways to Pollution Prevention”. NATO/CCMS Pilot Study “Clean Products and Processes (Phase 1)” 1999 Annual Report, Number 238, pages 45-48.

Introduction

Cleaner Production is conceptual and procedural approach to production, demanding that all phases of a product or process life cycle be addressed with the objective of preventing or minimizing short- and long-term risks to the humans and the environment. Cleaner Production utilizes improvements in product design, raw materials production, selection and their efficient use, as well as production and assembly of final products, consumer use of the products, waste and disposal recycling, transportation of raw materials and products, and energy savings. Specifically, adoption of Cleaner Production principles offers industry opportunities to promote operating efficiency while improving environmental performance. Source waste reduction eliminates costly post-production effluent control or bolt-on treatment. This conserves raw materials and energy, eliminates usage of toxic materials and reduces quantity and toxicity of all emissions and wastes in a closed-cycle process. For products, Cleaner Production spans the entire process life cycle from raw material procurement to disposal of byproducts of industrial material processing. Cleaner Production is achieved by applying know-how, by improving technology and changing attitudes. Cleaner Production is generally cost effective due to potential improvements of both process efficiency and improved product quality. These economic advantages of CP are especially evident when compared with other environmental protection strategies, for example such as end-of-pipe waste water treatment, waste processing, and exhaust gas treatment. Apart from cleaner production in industry, it is possible also to survey opportunities and constraints for cleaner energy conversion and improved energy utilization.

Part 1. Cleaner production strategy and TACTICS based on systematic approach to sustainable product development

Main principles of the cleaner production concept are as follows:

- All ecological problems should be solved in cooperation with a unified comprehensive planning.
- Ecologizing economy supposes modernization of objects, which are real or potential pollutants of environment.
- The prosperity of ecologizing implies existence of professionals skilled in the theory and practice of ecologizing, cleaner production and ecological management.
- The creation of civilized ecological market is a necessary prerequisite for ecologizing of economy and sustainable development of the country.

As known, the cleaner production concept as and sustainable development concept includes three aspects: ecological, economic and social. Underestimating any one of these components will bias the whole equation and infringe strategy of sustainable development. Indeed, reassessment of an economic force having underestimed ecological and social implications, results in infringement of stability of development, for it is impossible to ensure improvement of conditions of life of the next generation if the improvement of economy will not be accompanied by reduction of technogenic loads per capita, and mastering social problems of a community. Therefore, only mutually balanced simultaneous comprehensive tackling of the three tasks (economical growth with simultaneous improvement of ecological conditions and decision of social problems) will allow to realize progressive CP strategy.

The system analysis shows strong interaction and feedback among the mentioned three factors of CP strategy. In this regard, the strongest parameters determining stability of development are just those that render influence on at least two out of the three factors of Cleaner Production concept.
The increase of manufacture cleanliness renders influence on the economic and ecological characteristics of system, and, consequently, can be regarded as one of the basic Cleaner Production factors.

The set of engineering techniques and methods for Cleaner Production seems somewhat limited and lacking diversity. The reason may be in unwillingness to disclose know-how by some practitioners, or simply absence of new approaches. Anyway, a simple analysis shows that our western partners can offer only Cleaner Production tools and methods as follows: recycling, use of biotechnology, separative reactions, systemic approach, and industrial symbiosis. That is about all. Yet, effective methods to increase product cleanliness is something much bigger. For example, we are using the following Cleaner Production tools and methods:

- Recirculating flow of the least hazardous agent taken in excess over its stoichiometric value;
- Controlled heterogenization of the contacting phases for softer conditions and improved selectivity;
- Separative reactions: removal of reaction products at the moment of their formation;
- Synthesis and separation in an aerosol to increase intraparticle pressure and reaction rate;
- Self-excited oscillation of reacting phase flows at frequencies and amplitudes matching those at the rate-limiting tiers of the system;
- Flexible synthesis systems and adaptive equipment to embody them;
- Process engineering for high throughput to cut processing time and reduce byproducts and wastes, and industrial symbiosis as a basis for management of secondary materials and energy.

Some of these methods are little known in the West. But they may be used for joint development of Cleaner Production concept in the Ukraine and other countries. New environmental and Cleaner Production challenges in transition economies must be included in Cleaner Production concept realization. For example, there are severe environmental effects of restructuring, military conversion, privatization and economic transition. In any case, transition economies have no mechanisms for stimulating Cleaner Production technologies. It is desirable to use the systems approach in Cleaner Production Concept Implementation (or Cleaner Production Strategy and Tactics) for transition economies.

At the same time it is necessary to help Cleaner Production movement meet its economic goals in transition economies which have development features as follows:

1. Methodology for application of CP philosophy to economic restructuring, military conversion, privatization and economic in transition at a national or regional level.
2. Practicable program for embodying CP concept under sweeping changes in the NIS and other transition economies. (May be it desirable to launch a Special Pilot Project on Systems Approach to CLEANER PRODUCTION Concept Implementation (or CP Strategy and Tactics) for Transition Economies. In any case, transition economies have no mechanisms for stimulating CP technologies).
3. CP oriented priority-based investment programs for attracting investors to NIS.

We have some specific problems in the transition economies that need to be solved. For sample, CP approaches are concerned not only with production but also with transportation. The traffic has dramatically increased in Ukraine due to market development and occurrence of a great many of trade intermediaries and small businesses. This resulted in aggravated negative influence of transportation on environment, making cleaner transport a matter of survival and urging immediate and competent decisions. The "free" market has displaced regular grades of petrol for cheaper ones containing aromatics, that is hazardous byproducts of coke industry. These include benzene, toluene, xylene and others and their combinations. Expert judgment is that these aromatics cannot be burned in an engine completely and are massively discharged to air with exhaust gas. No research into amounts of aromatics in exhaust has been conducted. The analyses of government bodies generally do not include these compounds. Meanwhile, the content of aromatics like benzene in a fuel is limited by standards of advanced countries.

Cleaner Production main goal and objectives are:

1. Systematization of cleaner production general theory, strategy and tactics, search of the tools and methods based on a systematic approach as a foundation of sustainable product development in Pridneprovie.
2. Searching and elaboration of the economic mechanisms stimulating transition to CP technologies in conditions of transition economy.
3. Organizing of international collaboration, association, coordination and information of organizations and individuals dealing with CP.

Besides we need the specific steps and tasks to be proposed

1. Terms and definitions, unification of the terminology of Clean(er) Production.
2. Writing and editing in Russian and English a handbook or practical manual of CP.
3. Organizing of an online CP Help and Consulting Service.
4. A compendium of the best CP practices at a pilot project of transportation environmental problem realization for a large industrial city (for example, Dnepropetrovsk).
5. Launch a CP technology incubator or greenhouse.

Then we can receive some concrete results (deliverables) and expected outcomes:

1. A pilot project for demonstration of transportation environmental problem solving for a large Industrial city (for example, Dnepropetrovsk).
2. Handbook or practical manual of CP practices tools and methods.
3. Review to identify economic mechanisms stimulating transition to CP technologies in conditions of transition economy.
4. Online CP Help and Consulting Service.
5. CP technology incubator or greenhouse.

Main directions of PCPC's activities now are:

- elaboration of strategy and tactics for cleaner production, waste management, pollution prevention;
- system ecologizing of acting manufactures;

- development and introduction of methods of adaptation and rehabilitation of the population in conditions of the increased technical loads;
- development and realization of the program of sustainable development of an industrial region;
- continuous ecological training and education, based on the concept of active constructive ecology;
- development of the information at cleaner production technology and equipment.
- to demonstrate the economic benefits of pollution prevention and recycling to industry business operations.

For the decision of problems of *information exchange* we are ready together with other organization realize the following programs:

- Creation of computer information base at ecological engineering and technologies of cleaner production;
- Issue a periodic regional ecological electronic newspaper, distributing ecological information and experience of use of cleaner production in a region and in the world (with use of networks);
- Realization of active contacts to world community on exchange by the ecological information;
- Retraining of the experts of acting manufactures on directions resource saving and ecological technologies .

It's necessary to give the main attention not so much to cleaning of gases and liquids as to many non-waste technologies for processing of raw materials including but not limited to concurrent reaction-dividing processes, new effective methods of recycling using capillary and porous impregnation of waste materials, electric aerosol technology, and flexible chemical engineering.

And at last an important advantage in solving ecological problems is interdisciplinary approach via experience of various experts from different organizations with the purpose of the best decision making regarding specific problems.

Part 2. Cleaner production definition tools and methods based on systematic approach FOR systematic reduction of environmental loads (ECOLOGIZING OR "ecologization")

There is methodology and algorithm for systematic reduction of environmental loads (ecologizing or "ecologization"), based on the system analysis. This has allowed to formulate main strategic principles and define a tactical receiving to their realization.
Finally, this concept is not connected to fight with damage wastes pollution, but to deliver a process so that they were formed in the minimum amount (waste minimization).

The main strategic principles of proposed methodology:

1. The System approach prescribed in the base of proposed strategy for systematic reduction of environmental loads. It expects that previously, than problems on methods of industrial waste conversion or utilization choose will be solve, it is necessary to consider questions for systematic reduction of environmental loads at the tier of strictly production. It's very

important to realize economic justified variants of removal or essential waste reducing by selectivity of main process raising at the lowest hierarchical object tiers.
The System approach is shown in the next table:

1	TIER OF HIERARCHY	Frequency order	Dimension order, m	CLEANER PRODUCTION TOOLS AND METHODS
1	Manufacturing	0.001-0.01 s^{-1}	10^2	Industrial Symbiosis, Waste Management.
2	Plant item	0.1-1 s^{-1}	1	Pollution Prevention, Recirculating, Local neutralization of emissions
3	Installation	0.1-1 s^{-1}	1	Flexibility and adaptability of technology and equipment
4	Apparatus or machine	$1\text{-}10^4$ s^{-1}	1	Recirculating flow of the least hazardous agent, Isolation (close-looping in structure) of flows of substance and energy
5	Contact device	$1\text{-}10^4$ s^{-1}	$10^{-3}...10^{-6}$	Synthesis and separation in an aerosol, Controlled heterogenization of the contacting phases
6	Molecular level	$10^5...10^8$ s^{-1}	$10^{-9}...10^{-12}$	Minimization of time of processing, Surplus less toxic reagent, Oscillation of reacting phase flows, Separative reactions organizing

There should be a match between a tier in a hierarchy and the methodology of characterization, assessment or influence used at this tier.

1. We will have an maximum of cleaner production effect if to move on tiers in rising mode (from the lower tier to upper-level of system. In the event of above hierarchies of system levels it is necessary to move toward from 8 tier to 1 one.
2. At the choice of methods of influence to the system on limiting tier, it is necessary to follow a principle of correspondence, i.e. ensure a correspondence their parameters to the scale of limiting tier (for instance, it is necessary to select methods of influence, corresponding defining dimension order -frequency features on limiting tier).
3. One of the the most efficient cleaner production principles is integrated approach to the solving of the problems of industrial installations pollution decreasing. It is not only by using of low-waste technologies, not only by using an equipment for the local cleaning of gases and liquids, but, first of all - a decision of a complex problem on making an ecological engineering as unites of technology and equipment. Thereby, principle of integrated approach in this interpretation implies a simultaneous decision on a matter of apparatuses and technological optimization of processes.
4. For clean production raising it is necessary to ensure sufficiently high its flexibility level. Under flexibility is implied quantitative factor, reflective possibility of a technology and equipment functioning in the broad range of changing of external and internal parameters of installation with given values of level of forming the by-products. So, it’s possible to act upon the object, changing its flexibility.

5. It's possible to influence on the object to its intensify, using principle "repetitions in use resources and energies"
6. Maximum selectivity of syntheses and division principle is one of the most efficient one under the deep conversion of initial materials .

Algorithm for systematic reduction of environmental loads with some explanatory basing on stated above reasons is resulted below.

1. *DECOMPOSITION*. The analysis of the initial information including inspection of industrial manufacture, with the purpose of its decomposition on typical levels of hierarchy (for example, manufacture – plant item - installation –apparatus or machine - contact device - molecular level).

The system analysis recognizes that any system, including nature-technical, consists from taking place in hierarchical dependence under and upper-level subsystems. And the problem of maintenance of required ecological parameters at each hierarchical level carries individual character, while for realization of a general purposes - for systematic reduction of environmental loads of all system- it is necessary to establish the basic determining components of system, their external and internal connections, laws of functioning of system and connection of individual ecological parameters of a subsystem with a general integrated parameter of all system.

2. *IDENTIFICATION* of an initial level. Revealing of the bottom level of hierarchy limiting from the point of view of pollution to an environment.

3. *SELECTIVITY INCREASE*. Increase of selectivity of actually technological stages of processing at a limiting level of hierarchy.

For a choice of methods of influence it is expedient to use a database on tactical ecologizing receptions. Some of its principles have a common for technique character (repeated using, waste recycling and resource saving).Besides this database has also specific receptions for processing industries, in particular, for chemical, metallurgical, food branches of industry.

Except for ecologizing principles, the most common receptions for their realization, in particular, with reference to processing branches of manufacture are given in a database. Among them it is necessary to differentiate two closely connected among themselves groups of methods: regime-technological and apparatus – constructive ones. Alongside with traditional for any area of engineering methods (isolation of structure and multifunctionality of the equipment, intensification) the features of processing branches predetermine use of some special ecologizing methods.

Among them:

- Minimization of time of processing and surplus less toxic reagent, resulting all to increase of selectivity and reduction of formation of by-products,
- Synthesis and separation in an aerosol to increase intraparticle pressure and reaction rate,
- Self-excited oscillation of reacting phase flows at frequencies and amplitudes matching those at the rate-limiting tiers of the system,

- Recirculating flow of the least hazardous agent taken in excess over its stoichiometric value,
- Isolation (close-looping in structure) of flows of substance and energy by recirculating, resulting to "idealization" of modes of synthesis and significant reduction of speed of by-processes,
- Separative reactions organizing (synthesis and dividing processes organizing in the same palace and in the same time), allowing to reduce formation of by-products by removal of a target product from a reactionary zone at the moment of its formation,
- Controlled heterogenization of the contacting phases for softer conditions and improved selectivity,
- Flexibility and adaptability of technology and equipment allowing to ensure reliable work of technical system by "internal" reserves (flexibility) of installation using, that reduces an opportunity of harmful substances pollutions or reception of a sub-standard product.

If the expert is not satisfied with the result of work at this level, he has to rise to the next more high tier and to continue work.

Transition on next higher tier.
In connection with change of determining amplitudes and the frequencies at this tier, are used other cleaner production tools and methods.
First of all it’s Pollution Prevention and Recirculating. Modern ecologizing provides not neutralization of emissions "in general" in mixed polluting liquid or gas flows, but the local neutralization of emissions first whenever possible by each component, and secondly, as is possible closer to a source of their formation. This approach is alternative in relation to the principle, accepted in FSU (of creation of global clearing structures for neutralization or recycling at once of all scale of harmful emissions). So, the local for each component clearing as much as possible approached to sources of emissions, as has shown world experience, has appeared much more effectivecleaner production direction.

Transition on next higher tier.
Only after end of an actually manufactures CP stage it is necessary to begin the decision of questions of complex processing and recycling of sub-standard products and waste of manufacture. Here main methods are Industrial branch and interbranch Symbiosis and Waste Management.

The market economy requires thus, that the waste producer has ensured their transformation in secondary technogenous raw material. At the modern approach of installation of clearing or the recyclings should be a component of industrial object included in the basic technological line.

The following stage of the work is the realization of the technical and economic analysis of the chosen CP directions and methods with drawing up of accounts which are taking into account not only an expenses on CP and its results in sphere of manufacture, but also payments for resources, payments for above permitted standard emissions and other ecology-economic parameters.
The purpose of these accounts to determine priorities in the field of the investments in CP at all stages of life cycle of object and at all hierarchical tiers of object.
Only after that the experts make the choice of the ecology-economically justified CP variant .

For processing industries the especially important parameter of a CP degree is achieved and achievable results of performance of manufacture, as the increase of waste quantity promotes increase of expenses both on manufacturing, and on increase of total emissions of harmful substances in an environment.

$$Ji = \frac{P_{1i} - P_{2i}}{P_{maxi} - P_{2i}},$$

where P_{1i}, P_{2i}, P_{maxi} - accordingly, final, initial and maximal size of the factor determining calculated parameter.
The size $Đ_i$ can be as a uniform parameter quantitatively describing this or that property of system (for example, degree of dust-cleaning, factor of extraction etc.), and complex integrated parameter which is taking into account at once e of the some basic characteristics of object. Use or additive CP parameters in the latter case is expedient:

$$P_i = \overset{n}{\underset{j=1}{S}} K_j P_{ij},$$

where K_j - the importance of a j-parameter (is estimated by experts and changes within the limits of 0 + 1), or multiplicate CP factor:

$$J = \overset{ê}{\underset{i=1}{Ï}} J_i,$$

Having the quantitative characteristics of an ecological level of production, it is possible to compare the various technical decisions, to choose optimum and even to project new systems with the beforehand given level of influence on an environment. It will promote transition from “about-cleaner production” conversations to creation of actually cleaner installations, manufactures and enterprises.

UKRAINIAN COOPERATION PROPROSAL

Following the Ukrainian tour-de-table presentation, the Ukrainian delegate introduced the following cooperation proposal to the NATO/CCMS meeting for further consideration:

Proposals about cooperation

1. We would like to be included in a list of NATO/CCMS Project participants with one of the themes:

- Systematization of cleaner production general theory, strategy and tactics, search of the tools and methods based on a systematic approach as a foundation of sustainable product development.

(Terms and definitions, unification of the terminology of Clean(er) Production. Writing and editing in Russian and English a handbook or practical manual of CP, elaboration of strategy and tactics for cleaner production, waste management, pollution prevention; system ecologizing of acting manufactures; development and introduction of methods of adaptation and rehabilitation of the population in conditions of the increased technical loads; development and realization of the program of sustainable development of an industrial region; continuous ecological training and education, based on the concept of active constructive ecology; development of the information at cleaner production technology and equipment, demonstration the economic benefits of pollution prevention and recycling to industry business operations).

- Searching and elaboration of the economic mechanisms stimulating transition to CP technologies in conditions of transition economy.
- Organizing of international collaboration, association, coordination and information of organizations and individuals dealing with CP with use of modern information technologies (Russian – English CP Information – Consulting Net, organizing of an online CP Help and Consulting Service, Virtual INTERNET CP Exhibition – Market of CP Technology, CP Digest English - Russian version of "Constructive Ecology and Business Journal", Creation of computer information base at ecological engineering and technologies of cleaner production;).
- Launching a CP technology incubator or greenhouse.
- Retraining of the experts of acting manufactures on directions energy -resource saving and CP technologies (solving ecological problems on the base of interdisciplinary approach via experience of various experts from different organizations with the purpose of the best decision making regarding specific problems).

2. We are ready to organize one of the next NATO ARWs (jointly with one of the NATO member country):

- Methodology for application of CP philosophy to economic restructuring, military conversion, privatization and economic in transition at a national or regional level.

(Practicable program for embodying CP concept under sweeping changes in the NIS and other transition economies. May be it desirable to launch a Special Pilot Project on Systems Approach to CLEANER PRODUCTION Concept Implementation (or CP Strategy and Tactics) for Transition Economies. In any case, transition economies have no mechanisms for stimulating CP technologies. CP oriented priority-based investment programs for attracting investors to NIS).

- Problems of Cleaner urban transportation. A compendium of the best CP practices at a pilot project of transportation environmental problem realization for a large industrial city .

(We have some specific problems in the transition economies that need to be solved. One of them, CP approaches are concerned not only with production but also with transportation. The traffic has dramatically increased in Ukraine due to market development and occurrence of a great many of trade intermediaries and small businesses. This resulted in aggravated negative influence of transportation on environment, making cleaner transport a matter of survival and urging immediate and competent decisions. The "free" market has displaced regular grades of petrol for cheaper ones containing aromatics, that is hazardous byproducts of coke industry. These include benzene, toluene, xylene and others and their combinations. Expert judgment is that these aromatics cannot be burned in an engine completely and are massively discharged to air with exhaust gas. No research into amounts of aromatics in exhaust has been conducted. The analyses of government bodies generally do not include these compounds. Meanwhile, the content of aromatics like benzene in a fuel is limited by standards of advanced countries).

- CP and energy – resources saving at the military technique and rocket plants (on the base of NASA (USA) and NSA (Ukraine).

ROMANIA

ONE MORE STEP TO POLLUTION PREVENTION
Viorel Hârceag
Romanian delegate

Sustainable development requires real economic growth because only such growth can create the capacity to solve environmental problems. Steel is essential for economic development. It is the most important construction and engineering material available to modern society. The demand for steel grows at a high rate in developing countries. Each activity in the cycle of steel has a different perspective on its relationship with the complete system.

The natural and longest established closed cycle of steel explains the interest of steel in using life cycle assessment techniques as a valuable environmental management tool. Life cycle involves the evaluation of the impact of a steel-using product over its complete life cycle from raw material assembly through to steel production, the manufacture of the steel-using product, the working life of that product, the end of life disposal and the recycling of the steel it contains. The concept of life cycle assessment (lca) is to evaluate the environmental effects associated with any given activity from the initial gathering of raw material from the earth until the point at which all residuals are returned to the earth. Lca is a technical tool to identify and evaluate opportunities to reduce the environmental effects associated with a specific product, production process, package, or activity. Implementation of opportunities pointed out in the third stage of lca can be made using pollution prevention techniques.

In NATO/CCMS meeting held in 1999 in Belfast, I described LCA study in metallurgical field, in a sintering plant. It was conducted using US EPA methodology (LCA, how to do it, UNEP – Industry and Environment, ISBN 92-807-1546-1).

In the current paper is presented next step, LCA in iron production in blast furnace, conducted in the same manner. Iron production occurs in a blast furnace and involves the conversion of iron ores into molten iron by reduction with coke and separating undesirable components such as phosphorus, sulfur, and manganese through the addition of limestone.

The blast furnace is a counter-current reactor, loaded or charged from the top with layers of feed and coke, the molten iron and slag being drawn off from below. Hot air is injected in the opposite direction from the bottom of the furnace. Residual materials (waste) such as oily metal chips and oily rolling scale can be introduced after sintering. The principal emissions, residues and waste materials are:

- top gas, with the following potentially environmentally relevant components: CO, CO_2, SO_2, NO_x, H_2S, HCN, CH_4, As, Cd, Hg, Pb, Ti, Zn
- top gas dust (dry) from the gas cleaning plant with high iron contents (35 - 50%)

- slag with the following major components : SiO_2, Al_2O_3, CaO, MgO
- sludge from the waste gas cleaning system
- wastewater from the waste gas cleaning system, with the pollutants: cyanides, phenols, ammonia

The waste gases from the blast furnace are pre-treated in mass force separators (dust catchers or cyclones) and, in a second stage, finally cleaned with a high-pressure scrubber or wet electrostatic precipitators. Clean gas dust concentrations from 1 to 10 mg/m^3 are achieved. Other dust emissions in the blast furnace area, particular from the burdening process, pig iron desulphurisation and the casting house must also be identified and cleaned.

The top gas contains between 10 and 30, though possibly as much as 60 g/m^3 dust with 35 to 50% iron, i.e. 30 to 80 kg/t iron, in older plants 50 to 130 kg/t pig iron. The dust is separated in the dry state in mostly multistage separators, from where it goes to the sintering plant and from there back to the blast furnace. In view of the zinc and lead content and other factors, the top gas scrubbing water sludge must be disposed of by dumping, unless there is a special hydro-cyclone separation system. With higher concentrations, it should be transferred to a non-ferrous metal works. Recycling in this way would leave the blast furnace process practically free of residues. Dumping involves the risk of leaching and hence penetration of the soil and groundwater by compounds of zinc, lead and other heavy metals. The dump must be permanently and verifiably sealed and the seepage water must be collected and chemically processed. The special requirements imposed on such a dump must be laid down in the project planning stage. The top gas can be used as a fuel for heating purposes within the works, in view of its high carbon monoxide content due to the reducing atmosphere in the blast furnace, though this will inevitably result in the formation of carbon dioxide, with its climatic implications. Excessive levels of sulphur dioxide and nitrous oxide gases can be reduced by flue gas desulphurisation and denitrification.

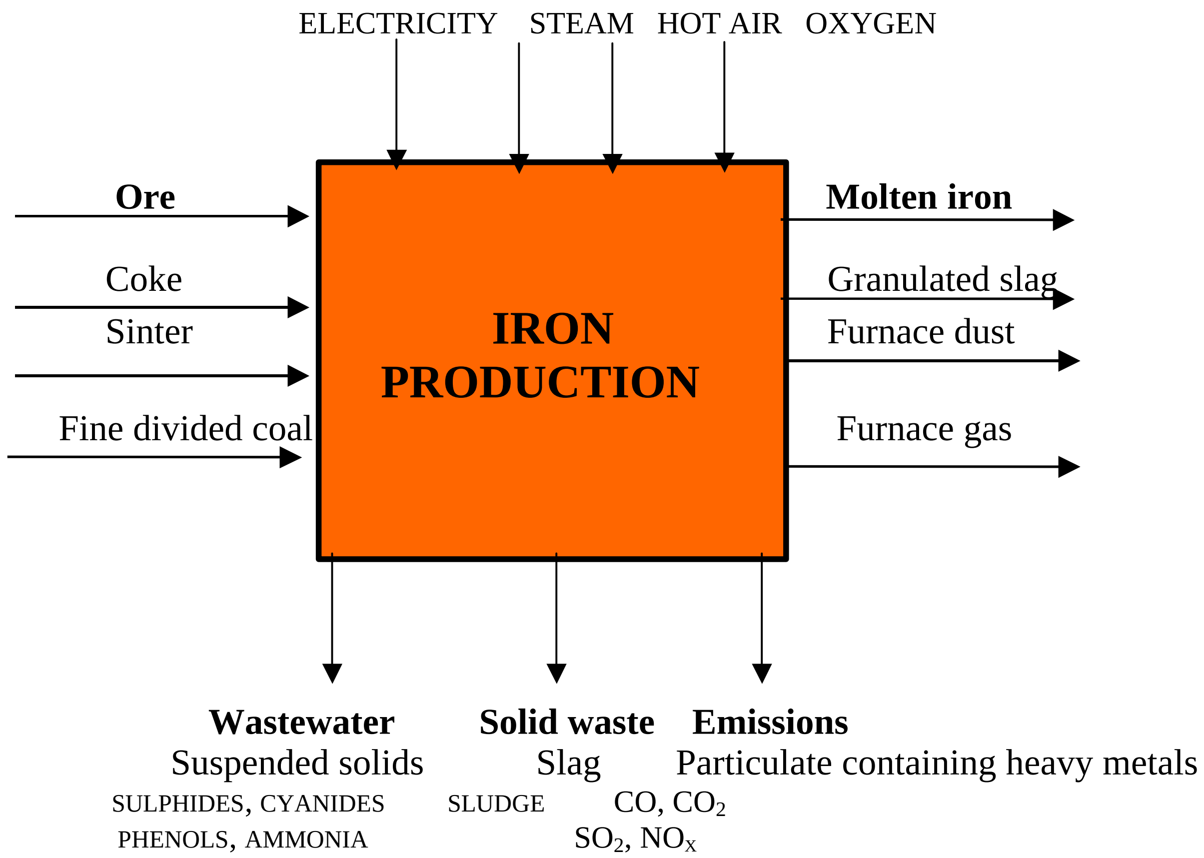
Slag produced by the blast furnace process accounts for roughly 50% of the overall waste materials from iron and steel production. This slag is mostly used in road building. Part of the molten slag is granulated by quenching in water. This so-called slag sand is also used in road building. Part is used to produce iron slag portland cement and blast furnace cement. Slag heaps sometimes produce seepage water with high levels of dissolved sulphides and strong alkaline reaction, posing a hazard for the groundwater. Slag heaps must be sealed and any seepage water must be treated.

Wastewater is generated by top gas scrubbing and simultaneous wet de-dusting. The wastewater is normally clarified in settling tanks and, where necessary, gravel bed filters and recirculated. The wastewater contains suspended matter (dust) and sulphides, cyanides, phenols, ammonia and other substances in dissolved form. The last three substances must be removed from the wastewater using appropriate physical and chemical treatment processes.

Carbon monoxide concentrations in the workplace pose a particular problem. Where top gas pipes are not perfectly leak proof there is a danger of poisoning with possible fatal consequences for workers present at the furnace throat. Close attention must also be paid to co concentrations by carrying out measurements and ensuring that protective breathing equipment is worn during repair and maintenance work on shut-down blast furnaces or gas cleaning systems.

Noise in blast furnace plants comes mainly from the combustion air fans and the charging process; also there is the noise generated upon changeover from blast to heating operation. Suitable abatement measures include silencers, enclosure of the furnace throat or encapsulation of all valves and shields. The noise level from the blast furnace plant is in the range of 110 to 125 db(a); the level of background noise in the immediate vicinity may be 75 to 80 db(a). Possible noise reduction measures should be selected as early as the blast furnace planning phase. Their effect can be determined by advance calculation, taking care to ascertain the significance of the emission sources (plant sections and operating processes). One should preferably begin by damping or eliminating occurrences and noise sources which arise only periodically.

Emissions produced by the iron and steel industry requires particularly extensive measures and systems for air protection. Above all, dusts containing substances hazardous to health and the environment, such as lead, cadmium, mercury, arsenic and thallium, must be cleaned by high-performance separation systems. Nowadays, not only the primary emission sources, such as sintering plants, but also secondary sources such as blast furnace casting bays can be intercepted and dedusted. In the case of gaseous emissions, attention must be paid primarily to reducing carbon monoxide and sulphur dioxide, as well as nitrous oxides and fluorine compounds.



Iron fabrication flow chart

The execution of inventory stage results in a set of data sheets and growing insight into the availability of information. So, in the following tables is shown the environmental data sheets that includes raw materials, energy inputs and air pollutants outputs of the process fabrication for one ton of iron.

Environmental data sheet
PROCESS: Iron fabrication

Furnace no.2

	Kg/tone	Quantity (tones)	Notice
Product – Molten iron	1,000	404,000	
Co-products – Furnace gas (Nm^3)	2,189	884,356	recycled
Furnace dust	10	4,040	recycled
Fine treatment sludge	5	2,020	recycled
Granulated slag	151	61,004	recycled
Wastes – Dumped slag	280	113,120	At the dump
Wreckage	5	2,020	At the dump
Metallic wastes	10	4,040	recycled
Technological losses	92.2	37,245	Difference

Furnace no.3

	Kg/tone	Quantity (tones)	Notice
Product – Molten iron	1,000	454,482	
Co-products – Furnace gas (Nm^3)	2,074	942,595	recycled
Furnace dust	10	4,545	recycled
Fine treatment sludge	5	2,272	recycled
Granulated slag	148	67,263	recycled
Wastes – Dumped slag	275	124,982	At the dump
Wreckage	5	2,272	At the dump
Metallic wastes	10	4,545	recycled
Technological losses	107.3	48,766	Difference

Furnace no.4

	Kg/tone	Quantity (tones)	Notice
Product – Molten iron	1,000	547,551	
Co-products – Furnace gas (Nm^3)	2,070	1,133,431	recycled
Furnace dust	10	5,475	recycled
Fine treatment sludge	5	2,738	recycled
Granulated slag	144	78,848	recycled
Wastes – Dumped slag	267	146,196	At the dump
Wreckage	5	2,738	At the dump
Metallic wastes	10	5,475	recycled
Technological losses	112.6	61,654	Difference

Furnace no. 5

	Kg/tone	Quantity (tones)	Notice
Product – Molten iron	1,000	1,025,220	
Co-products – Furnace gas (Nm^3)	2,104	2,157,062	recycled
Furnace dust	10	10,252	recycled
Fine treatment sludge	5	5,126	recycled
Granulated slag	150	153,782	recycled
Wastes – Dumped slag	240	246,052	At the dump
Wreckage	5	5,126	At the dump
Metallic wastes	10	10,252	recycled
Technological losses	91.4	93,705	Difference

Furnaces 2 – 5

	Kg/tone	Quantity (tones)	Notice
Product – Molten iron	1,000	2,431,253	
Co-products – Furnace gas (Nm^3)	2,130	5,178,569	recycled
Furnace dust	10	24,312	recycled
Fine treatment sludge	5	12,156	recycled
Granulated slag	151	367,119	recycled
SLAG FOR BRICKS	-	1,082	used
Wastes – Dumped slag	259	629,694	At the dump
Wreckage	5	12,156	At the dump
Metallic wastes	10	24,312	recycled
Technological losses	97.5	237,047	Difference

Each input component of iron fabrication coming with its own energy and raw materials consumption and its own pollutant emissions, data which are similarly centralized in environmental data sheets (not presented in this paper) for the main following components processes: iron ores preparation, coke production, sinter production and electricity production. All data from the environmental data sheets were centralized in the inventory table.

Iron production
Plant: Furnace no. 5
Year: 1999 April - May

Energy resources (GJ)			**Product and Co-products**		
Electricity	5,465,250	KW	Molten iron	156,150	t
Coke	66,364	T	Granulated slag	21,861	t
Fine divided coal	19,519	T	Furnace gas	327,915x10^3	Nm^3
			Furnace dust	2,342	t
			Air emissions		

Raw material resources			Particulate (Partic.)	30	t
Sinter	234,225	T	CO	3,771,023	Nm^3
Pelettes	17,177	T	CO_2	3,934,980	Nm^3
Ore	18,738	T			
			Waste water		
			Suspended solids (SS)	0.008	t
Hot air	$202{,}995x10^3$	Nm^3			
Steam	2,030	T	**Solid wastes**		
Oxygen	48,406,500	Nm^3	Fine treatment sludge	1,093	t
			Dumped slag	40,599	t
			Wreckage	781	t

The contribution of each main process was adjusted, using a ***contribution factor***, which represents the relative contribution of that process to the fabrication of one ton of iron.

Inventory table for 1 ton of iron

Energy resources (GJ)			**Product and Co-products**		
Electricity	35	kW	Molten iron	1,000	kg
Coke	425	kg	Granulated slag	140	kg
Fine divided coal	125	kg	Furnace gas	2,100	Nm^3
			Furnace dust	15	kg
			Air emissions		
Raw material resources			Particulate (Partic.)	0.2	kg
Sinter	1,500	kg	CO	24.15	Nm^3
Pelettes	110	kg	CO_2	25.20	Nm^3
Ore	120	kg			
			Waste water		
			Suspended solids (SS)	0.051	g
Hot air	13	kg			
Steam	1,300	Nm^3	**Solid wastes**		
Oxygen	310	Nm^3	Fine treatment sludge	7.00	kg
			Dumped slag	260	kg
			Wreckage	5.00	kg

Inventory analysis results are the base of ***impact assessment***. This stage of LCA consist in: *classification* – specifies which environmental problems are to be included in the analysis of iron fabrication, *characterization* – quantifies the environmental impacts, and *valuation* of classification and characterization results.

Raw materials consumption and pollutant releases for iron fabrication, according with the inventory table, can produce following environmental problems: Global warming (GW), Photochemical oxidant creation (PO), Human toxicity (HT), Eco-toxicity (E), Abiotic depletion (AD), Energy depletion (ED), Acidification potential (AP), Nitrification potential (NP), Ozone depletion (OD). To estimate the environmental impact of iron fabrication, for each environmental problem presented, has used an *equivalency factor*, measured as follows:

- GW = measured relative to the effect of 1 kg CO_2;
- PO = measured relative to the effect of 1 kg ethylene;
- HT = measured as the human body weight that toxicologically acceptable limit by 1 kg of the substance;
- E = volume of water that would be polluted to a critical level by 1 kg of substance;
- AD = measured relative to global supplies;
- ED = measured as MJ/kg or MJ/m^3;
- AP = measured relative to the effect of 1 kg SO_2;
- NP = measured relative to the effect of 1 kg phosphate;
- OD = measured relative to the effect of 1 kg CFC.

The values of each impact parameters in the inventory table were multiplied by the values of equivalency factor correspondents. The results are presented in table below; note that one parameter may score under several environmental problems simultaneous. The final result consists in a score for each environmental problem analyzed, which can give an image of possible impact produced by iron fabrication.

Classification and characterization for 1 ton sinter fabrication

	Raw materials Kg	*Ener-gy* GJ	**Air emissions** kg						**Wastewater** kg		
			Partic.	CO_2	CO	NOx	SOx	COV	CCO	SS	
Inventory Analysis	3,600.50	14.74	70.91	402.55	24.82	3.33	6.59	1.94	0.44	0.89	
Equivalence factors											
GW(kg/kg)	-	-	-	1	-	-	-	-	-		
PO (kg/kg)	-	-	-	-	-	-	-	0.38	-	-	
HT (kg/kg)	-	-	4.75	-	0.01	0.78	1.2	-	-	0.02	
E (kg/kg)	-	-	3,500	-	-	-	-	-	-	-	
AD (-/kg)	$1x10^{-12}$	-	-	-	-	-	-	-	-	-	
ED (GJ)	-	1	-	-	-	-	-	-	-	-	
AP (kg/kg)	-	-	-	-	-	0.7	1	-	-	-	
NP (kg/kg)	-	-	-	-	-	0.13	-	-	0.02	0.33	
OD (kg/kg)	-	-	-	-	-	-	-	-	-	-	
Multiplied characterization results											**TOTAL**
GW(kg/kg)				402.55							402.55
PO (kg/kg)								0.74			0.74
HT (kg/kg)			336.8		0.25	2.60	7.91			0.018	347.58
E (kg/kg)			248,185								248,185
AD (-/kg)	$3.6 \cdot 10^{-9}$										$3.6x10^{-9}$
ED (GJ)		14.74									14.74
AP (kg/kg)						2.33	6.59				8.92
NP (kg/kg)						0.43			0.009	0.30	0.74
OD (kg/kg)	-	-	-	-	-	-	-	-	-	-	-

Classification and characterization provides an environmental profile of a product, which consists in a set of scores on environmental problems in absolute figures. So, for iron fabrication, the greatest problems are lied by the ecotoxicity (E), due to the presence of heavy metals in the particulate emissions. Particulate are also responsible for human toxicity (HT), which obtained a high score, like the environmental problems lied by the global warming (GW), due to the great CO_2 quantity from pollutant emissions. A smaller score was obtained by energy depletion (ED), because of energetic consumption and acidification potential (AP), caused by SOx and NOx emissions from gases released in the sintering and iron production process. Very small scores have presented by photochemical oxidant creation (PO) and nitrification potential (NP), abiotic depletion (AD).

The results of the inventory analysis and impact assessment conduced to study the effects on the environment produced by processes components of iron fabrication system (iron ores preparation, coke production, electricity production and sintering), in the frame of ***improvement analysis***. We can remark that:

- the greatest particulate quantity arises from iron ores preparation process;
- the greatest quantity of pollutant gases arises from sintering and coke production;
- the greatest consumption of energy is achieved in the sintering and iron production;
- the greatest quantities of waste water arises from coke production;
- the greatest quantities of solid wastes arises from iron production process.

The finding of this interpretation may take the form of conclusions and recommendations to decision-makers, grouped in:

- actions to reduce electricity;
- actions to minimize pollutant emissions.

It is necessary to take the following measures:

☺ ***Efficiency increasing as a result of sintering installation improvement* by:**

- advanced control of burning front
  - ⁕ best distribution of coke granulation in sintering bed;
  - ⁕ best gases permeability through sintering bed as a result of good preparation of raw materials;
  - ⁕ reduction of false air exhausting;
  - ⁕ modernization of ignition system with the purpose of fast start burning at high temperatures (lead to a decreasing of coke-oven gas consumption).
- increasing of heat use efficiency
  - ⁕ reusing of gas heat for preheating of combustion air (this is lead to an increasing of flame temperature) and raw materials;
  - ⁕ reusing the heat of sinter cooling air for preheating of combustion air and raw material – when cooling air have low temperature – or for steam production – when cooling air have high temperature;
  - ⁕ reduction of heat losses as a result of decreasing of sinter returned material;
  - ⁕ recirculation of sintering gases.

☺ Diminution of energy spending and of wastewater and gases emissions, by fractional replacing of coke with fine divided coal (up to 200 kg / tone of iron produced).

☺ ***Reduction of dust emissions*** can be done first of all by best handling operations of raw materials. So, reusing of fine blast furnace dust and fine sintering dust must be forbidden without a previous pelletising.
Taking in consideration the big quantity of dust, which is in preparation shops, must be installed, where there are not, a hood, or resizing the exhaust system.
Because the dust is in a great quantity in the zones where air, respective the cool air have high temperature, an efficient method to reduce the level of dust emissions is recovery of heat eliminated with cooling air.
☺ ***Reduction of SOx emissions*** to stack can be realized by using raw materials and fuels with low level of sulphur (when that is possible).
☺ ***Reduction of NOx emissions*** in combustion gases is possible by diminishing the volume of false air exhausted and by improving the burning.

Few months after the end of this assessment, some people have cleaned an annex facility of examined furnace no. 4. They do not respected technological prescriptions and an explosion took place killing 2 people and hurting other 8. Conducted LCA do not contain any data about this possible accident.

In the impact assessment stage of LCA we have used US EPA criteria to estimate the environmental impact of iron fabrication. The accident occurrence impels me to make the proposal to supplement the above mentioned criteria with one more item, related to industrial accident potential (AP). It have to be multiplied with a statistic (probabilistic) coefficient, and can be measured in kg TNT in case of explosion potential or in terms of toxicity if the potential accident can release toxic substances:

AP x k (occurrence probability) = measured relative to the effect of 1 kg TNT

USA

SUSTAINABLE DEVELOPMENT – NEW CHALLENGES TO ENVIRONMENTAL R&D

Subhas K. Sikdar
Pilot study director and US delegate

Several significant events in the past year presented newer challenges to environmental R&D in the US EPA. The National Risk Management Research Laboratory has begun asking questions on sustainable development that require answers from science, technology, and economic perspectives. There are two focus areas for these queries. First, we want to develop a scientific framework for sustainability, which can perhaps be defined and measured. Second, we would attempt to identify a small set of robust criteria for describing place-based sustainability, be it a watershed or an urban setting. Emission of mercury from coal-fired power plants has surfaced as a big issue recently. Elemental Hg escapes through electrostatic precipitators and ends up in soil and water bodies. Mercury in fish poses danger to consumers. A cleaner power plant would have to remove the mercury from the flue gas itself, perhaps by adsorption on finely divided, high surface area, sorbents. Methyl t-butyl ether (MTBE) used in gasoline for octane boosting and for reducing tropospheric ozone in urban areas, has come under stiff consumer resistance. The State of California has declared a phased withdrawal of MTBE from the market, with the Federal Government following suit. Banning does solve the longer-term problem, but the urgent concern is to remove it from drinking water sources, perhaps at the point of use in the water works. Technologies in the latter two areas are critical needs. RETURN TO CONTENTS PAGE

TOUR DE TABLE PRESENTATIONS